



MEET THE SciDAC VISUALIZATION
AND ANALYTICS CENTER FOR
ENABLING TECHNOLOGIES



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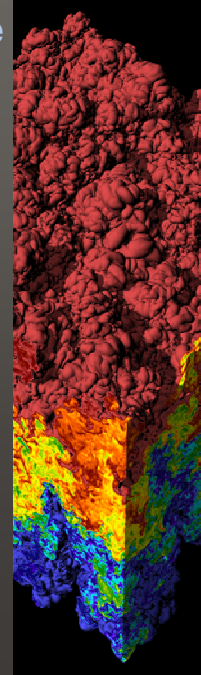
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VACET Deploys Technology for Petascale Visual Data Analysis

- Why VACET?
 - Visual data analysis is the centerpiece of scientific discovery.
 - Coordinated efforts in visual data analysis research, development and deployment.
- VACET Mission Statement
 - Meet visual data understanding needs of the DOE/SciDAC science community.
 - Adapt, extend, create when necessary, and deploy visualization and data understanding technology for SciDAC2 science stakeholders.
- VACET Delivers Production Quality, Petascale-Capable Visual Data Analysis Software Infrastructure
 - VACET Team includes staff from DOE's Open Computing Facilities (NERSC/LBNL, LCF/ORNL)

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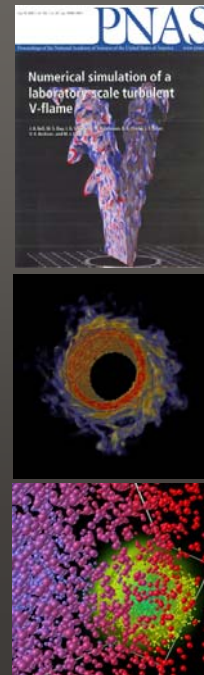





VACET Offers to Science Applications:

- Expert assistance in solving visual data understanding problems.
 - Long-term relationships with science applications in the spirit of SciDAC collaborations.
 - Our objective – help you do science more effectively.
- Production-quality, petascale capable visual data analysis software infrastructure
 - For visual analysis of large, complex datasets.
 - Presently installed and operational at NERSC, NCCS.
- New technologies for visual data understanding
 - Technical focus areas on next slide.
 - Rapid deployment in production-quality infrastructure at DOE's open computing facilities.


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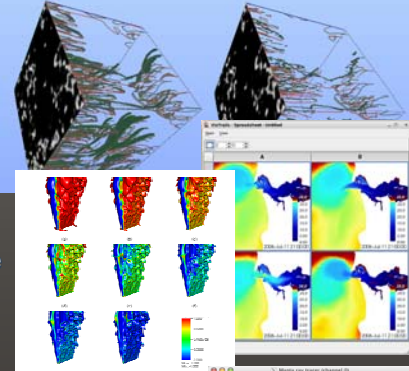
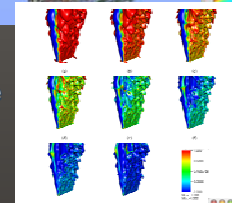
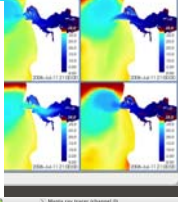


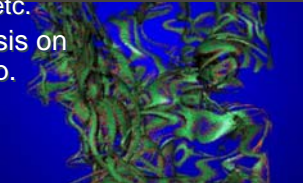
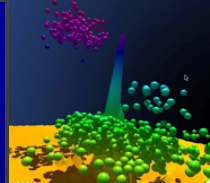
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VACET Technical Focus Areas



- Feature detection, tracking and analysis.
 - Topology-based
 - Data ranges
- Comparative visualization and analytics.
- Multivariate and temporal visual data analysis
- Remote/distributed visualization.
- Project-wide visual data analysis software infrastructure.
 - Tools tailored for use by targeted communities.
 - Publication quality, quantitative, etc.
- Large, complex visual data analysis on platforms from desktop to petaflop.

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Image notes:

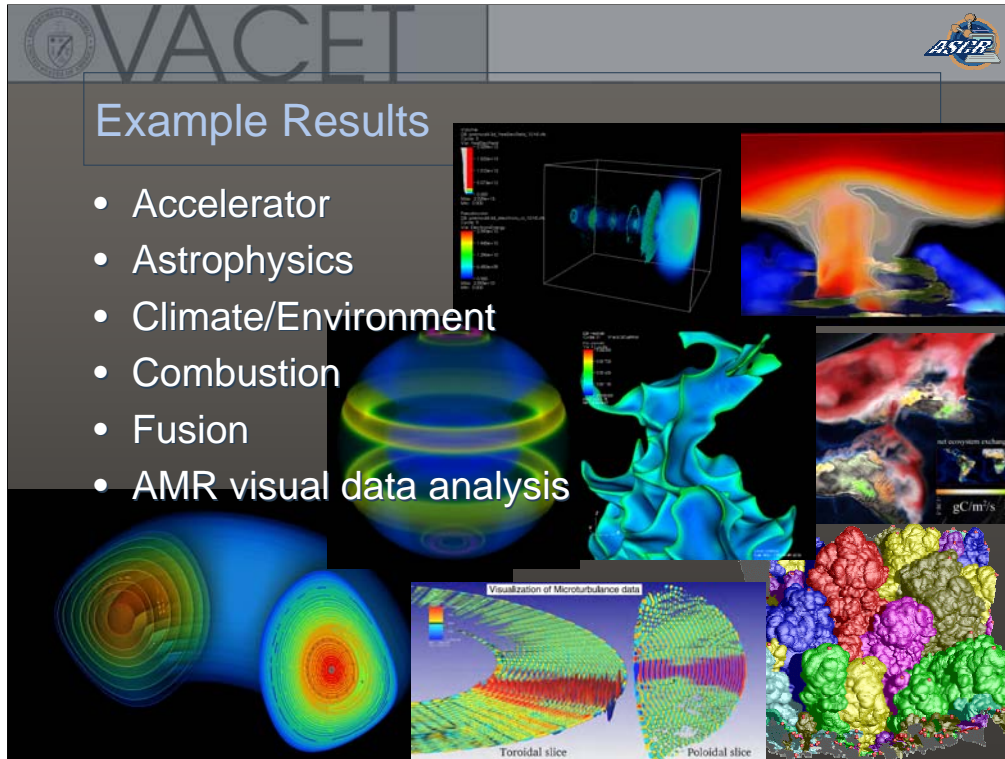
Top (cyan background): Feature tracking in a 2D simulation of an auto-ignition process. (Left) Tracking of all features; (Right) Tracking after space-time simplification. (Data courtesy J. Chen, SNL-CA)

Middle-left: This study shows visualizations indicating the correlation between H₂O and C₂H₄ on a surface of constant temperature. The temperature isotherm is increasing from upper left to bottom right; the resulting color changes indicate that correlation between H₂O and C₂H₄ is not independent of temperature. (Data courtesy J. Bell, LBNL)

Middle-right: This set of four images shows visualizations of fresh-water discharge from the Columbia River for different time steps. Each visualization is derived by a different workflow process. The overall objective here is to perform comparative analysis of time varying data. (Data courtesy ???)

Bottom-left: This image, created from a combustion simulation where data is stored in AMR format, uses a color map to indicate velocity magnitude on cells where the CO concentration is greater than or equal to 0.044. (Data courtesy J. Bell, LBNL)

Bottom-right: The height field represents particle density from a VORPAL dataset of a laser wakefield acceleration model. The spheres are individual particles whose velocity exceeds a specified threshold. (Data courtesy P. Hamill, Tech-x Corp)



Example Results

- Accelerator
- Astrophysics
- Climate/Environment
- Combustion
- Fusion
- AMR visual data analysis

Top-left: Visualization of VORPAL output modeling a Laser Wakefield accelerator model showing electric field charge and particles trapped in the wakefield. (Data courtesy C. Geddes, LBNL)

Top-right: Carbon-dioxide from various sources that are advected individually as tracers in the atmosphere model. Carbon dioxide from the ocean is shown as plumes during the period Feb. 1990. (Data courtesy ???) (Image courtesy of Forrest Hoffman and Jamison Daniel of ORNL.)

Middle-left: Volume rendering of entropy field from a radiation/hydrodynamic core collapse supernova simulation. (Data courtesy Adam Burrows, U of Arizona)

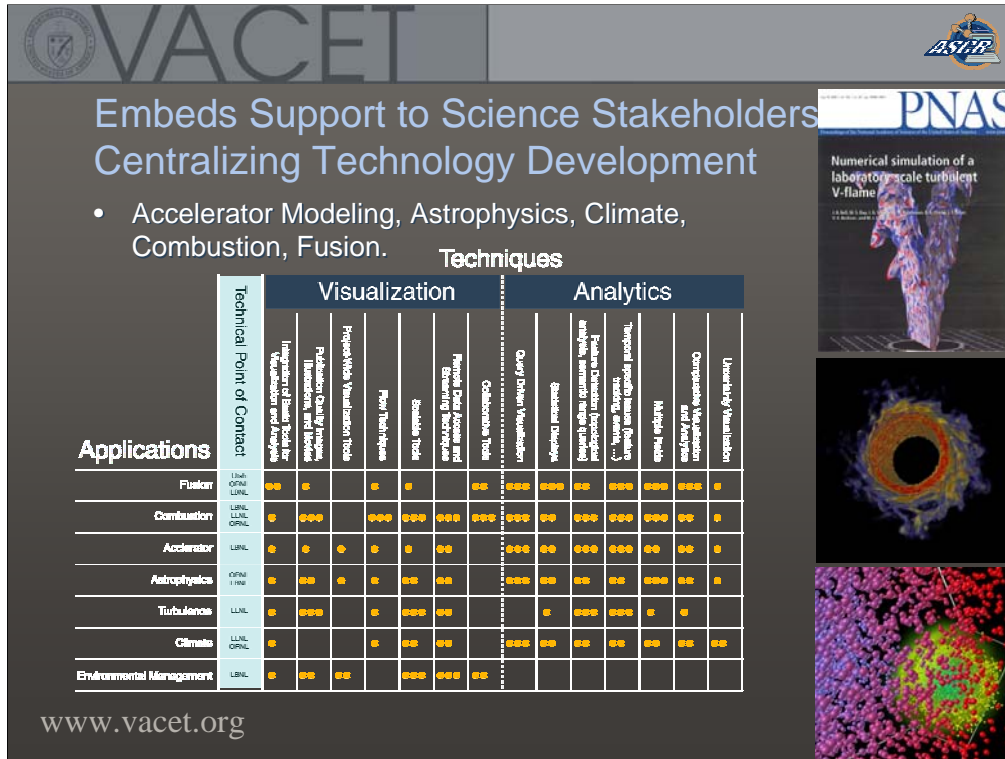
Middle-middle: CH₄ concentration on isotherm from combustion simulation with reactive chemistry. (Data courtesy of J. Bell, LBNL)

Middle-right: The image shows the component of the atmospheric CO₂ concentration that results from the net ecosystem exchange (NEE), which is shown on the land surface. This "green CO₂" is the flux due to the respiration of vegetation, respiration of soil microbes, and fire minus that taken up by ecosystem production. (Data courtesy ???)

Bottom-left: A visualization of a silo fusion MHD data set (Raul Sanchez ORNL) showing a series of iso-temperature surfaces with a Poincaré plot of the magnetic field overlayed. The analysis of the Poincaré plot located a set of magnetic islands with their "O" points demarcated with a gray sphere.

Bottom-middle: (Need caption, credit for data source, who did this image?)


Bottom-right: Tracking of bubble structures in the mixing interface of a Rayleigh-Taylor mixing fluid simulation. (Data courtesy ????)




This slide shows an applications/technology matrix: each science application (rows) has expressed data understanding needs (columns) along with a relative priority: three dots means urgent, need-now priority, while one dot means they need it within a year or two.

From this matrix, we draw several conclusions:

- There is no “one size fits all” visualization solution that meets the needs of all science applications.
- Organized as a Center, we are well positioned to draw upon diverse resources – expertise of team members reflecting technical capabilities across the “Techniques” (columns) – to provide integrated solutions that are responsive to the needs of our science stakeholders.
- Through careful software engineering and deployment, technologies VACET develops for one area will be immediately applicable to customers in other science areas.

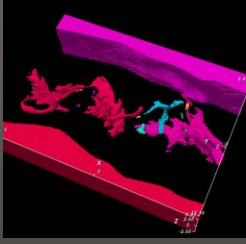
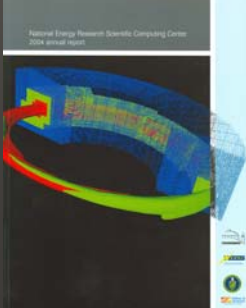


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Relationships with Other Centers

- Scientific Data Management (SDM Center)
 - Index/query technology to quickly locate data of interest in large collections.
 - High performance, parallel I/O.
 - Visualization technology in scientific workflow management systems.
- Mathematics (APDEC)
 - Adaptive mesh refinement data visualization and analysis.
 - Common science customers.
- Others:
 - ITAPS (meshing API, cross-mesh comparative analysis), TASCs (component software engineering).

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SDM Center

-Produces technology for indexing/querying (compressed bitmap indexing) that is used to quickly locate interesting data in large collections. VACET will leverage this technology to accelerate visualization and analytics tasks for petascale data understanding problems. This combination is a promising approach for “finding needles in haystacks”, where scalable technologies are used to focus visualization and analytics processing on “interesting scientific data,” thereby increasing the likelihood of scientific discovery and insight.

-High Performance I/O. The SDM Center has produced libraries for performing high performance parallel I/O that is used by some science applications (Climate) for quickly writing simulation results to disk. VACET will leverage this same infrastructure to quickly load large datasets during visualization and analytics processing on large parallel machines.

-Emerging technologies for scientific workflow management – orchestration of computation, data storage/movement/conversion – will naturally include visualization and analytics as part of the overall workflow.

Math Center – APDEC (Applied Partial Differential Equations Center)

-Uses Adaptive Mesh Refinement to achieve extremely high effective spatiotemporal resolution in simulation.

-AMR Visualization and analytics, which is one of VACET's specialties, poses special challenges; VACET will deploy scalable technologies for AMR visualization and analytics.

-VACET and APDEC will share many science customers: fusion, accelerator, astrophysics, combustion.